ME 424: Get Bent

Team Members:

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Mentor: Colin Burkhalter

A. Objective

Build and test a Sheet Metal Fatigue Fixture that can be used for cycling an aluminum sheet metal sample and produce a valid S-N curve describing its fatigue properties.

B. Value Proposition

Value Proposition and examples of real-world problem we would like to solve:

Limited data is available for characterizing fatigue properties of aluminum sheet metal materials, and its inherent non-isotropic grain structures make this characterization more difficult to accomplish.

A new device to measure fatigue properties of sheet metal using a variety of sample geometries will enable advanced research to characterize aluminum materials.

A previous capstone design team (in collaboration with SEL) initiated design of such a fixture, developing a strong foundation for a functional system. However, several key attributes of the system including the crankshaft mechanism that cycles the samples, failure detection of a sample, speed calculations to determine the number of cycles, and protective shielding, are not fully developed.

The goal of this team is to design a reliable way to cycle the sample, calibrate and use the load cell, programmatic detection of sample failure and frequency, build a prototype device, and evaluate its functionality.

Our design will cycle an aluminum sample, detect loading and compute stresses. A protective shield will keep operators safe and reduce noise.

C. Product Requirements

Senior Capstone Design

Project: SEL- Sheetmetal Fatigue Fixture

Team: Get Bent **Date: 6/24/2020**

Product Requirements

4 Functional Requirements:

Reasonable repeatedbility for experiments - User may expect that the same experiement should yield similar results
Range of error cannot exceed 15%

User Interface Requirements:

Sample Mounting	<45	minutes
Interface	Exportable	Data
Adjust for vary sheet metal bend degrees		

What the product should do: Fixture should stress the material to failure and record the # of cycles.

5 Mechanical Requirements:

Strength Requirements:

Maximum stress	40000	psi
Maximum Force	100	lbf

Spatial Requirements:

The fixture shall fit within the following:		
Overall Length	36	in
Overall Width	36	in
Overall Height	60	in
Max Length	11.74	in
Min. Length	4.25	in
Max Width	6	in
Min. Width	0.5	in

Weight/Mass Requirements:

Maximum weight	70	lbs

Pinch points

Eliminate pinch points	Shielding

Functionality Requirements:

Run time between maintenance	10000	Hours

Test Aluminum and Plastic
Fixture should fit on a bench/desktop
Setup time should take less than 45 minutes
Fixture should run from a wall socket
Fixture must be fully and partially reversible

6 Electrical Requirements:

Must use a single standard (US) electrical outlet

Voltage:

Normal Operation	120	V

Power:

Peak load	1500	W
Average load	200	W

7 Software Requirements:

Functionality: The software for the produce must be able to:

Handle up to 40 kisi of Static Stress

Configure the operating force and frequency for a test run		
Frequency range should be 1-100 HZ		
Calculate the S-N curve using the results from multiple test runs		
Generate a report as an Excel spreadsheet or CSV that contains the following:		
* Name of the material		
* Time to failure, frequency, and force for each test run		
* A plot (or a series of points to create a plot) of the S-N curve for the material		
Export report to a USB thumb drive or email.		
Should recieve a signal if process is interrupted for any reason except material failure and when the sample has finished		
Must be able to run without continuous human interaction.		

8 User Interface:

The User interface must be easy to view and interact with.		
User preference for mounting samples	Y Allen bolts	Y Allen Wrench
Ability to change center / load cycling rollers start height	X bolts	X End Wrench
Ability to accurately change length between side support rollers	X bolts	X End Wrench
Ability to adjust backstops	X bolts	X End Wrench
Ability to replace endplate sample holder	Y Allen bolts	Y Allen Wrench
Recommend sample size given desired stress		

X and Y represent a standard size for the fastener that will be determind later

Environmental Requirements:

Noise:

Operational noise	<80	Decibles(db)
Must not interrupt normal office environment.		

9 Cost Requirements:

Prototype Cost:

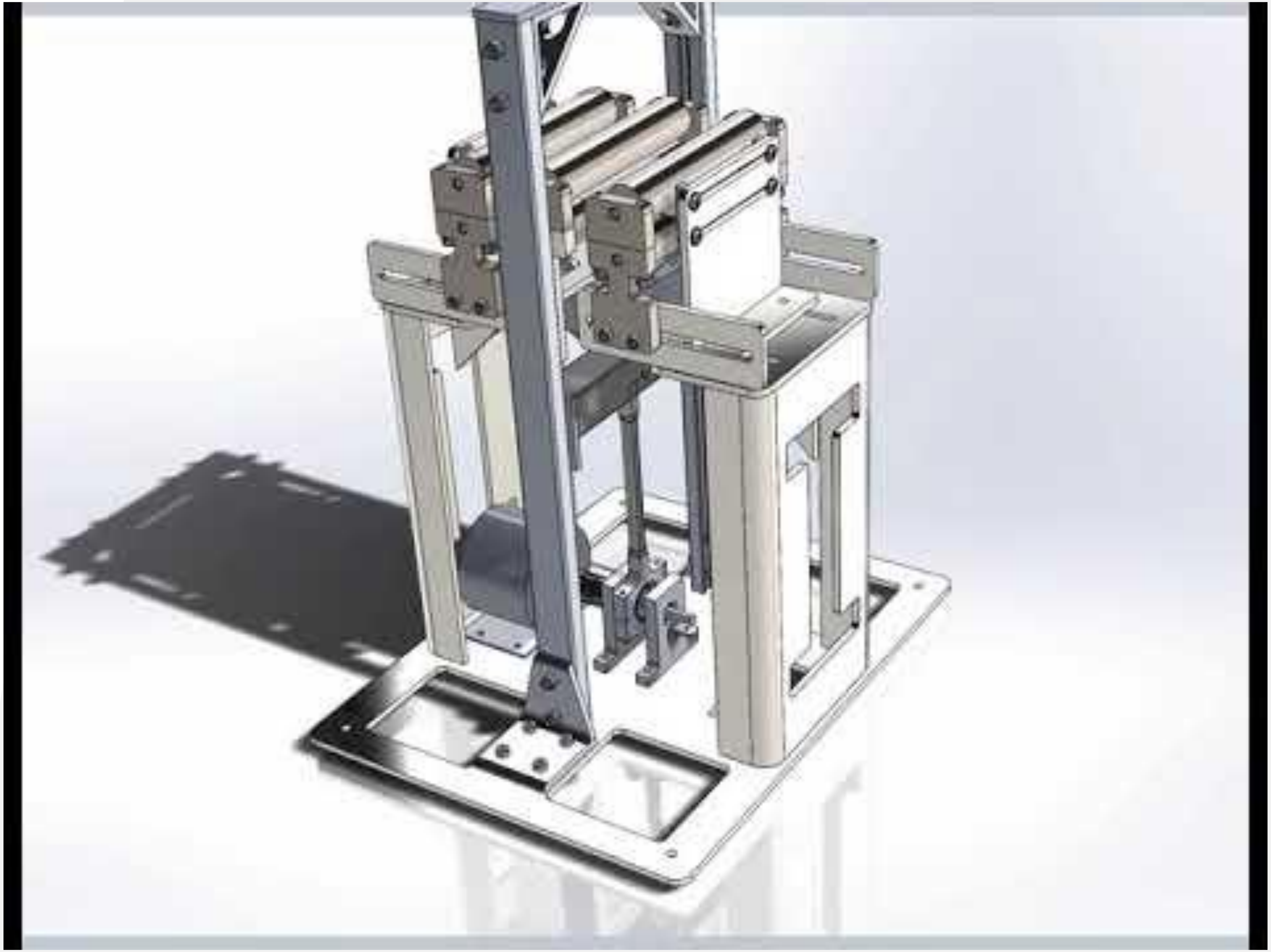
Maximum cost to build proof-of-concept prototype	$ 2,166	

Production Requirements

Maximum cost of production units	$ 2,000	

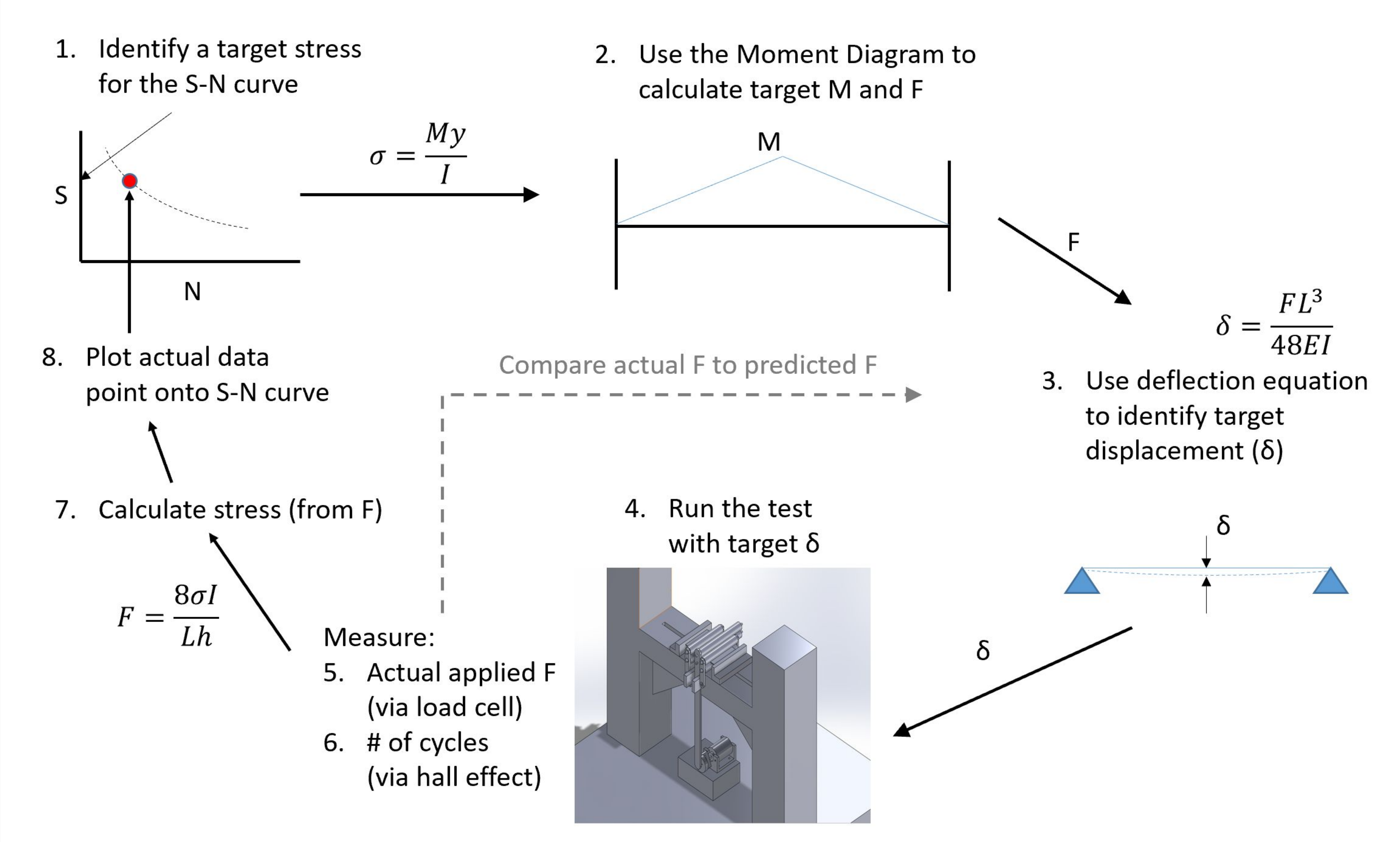
D. Product Development

University of Idaho



Variable Deflection?

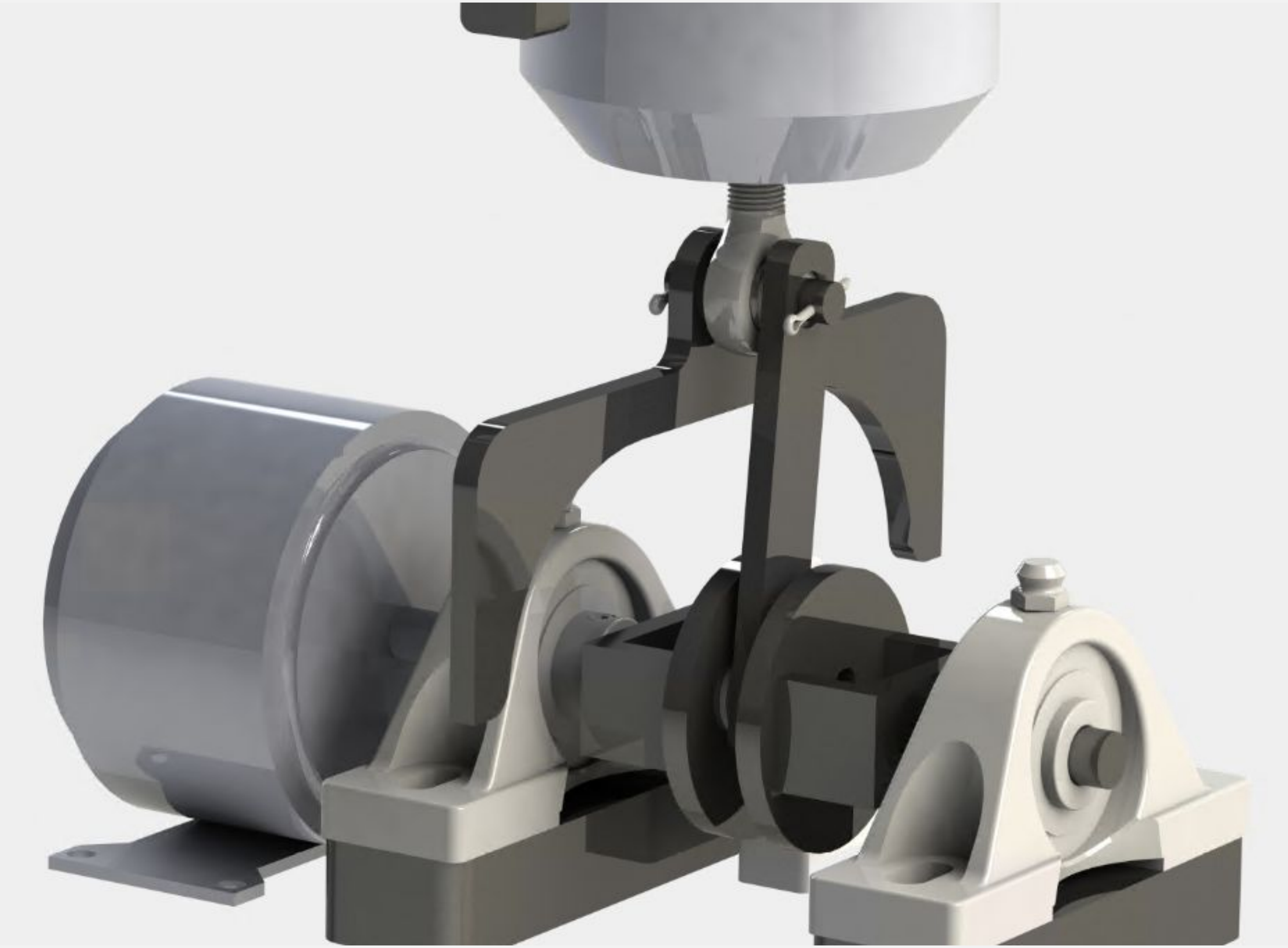
- Prior team had decided a variable deflection was necessary to obtain a useful range of stresses



Potential Issues Regarding Variable Deflection:

- **Accuracy challenges**
- **Time constraints (Difficult to design suitable solution within project time frame)**
- **Difficulty producing replicable displacements**

Prior Teams Load Cycling Mechanism Design:



Fixed Deflection

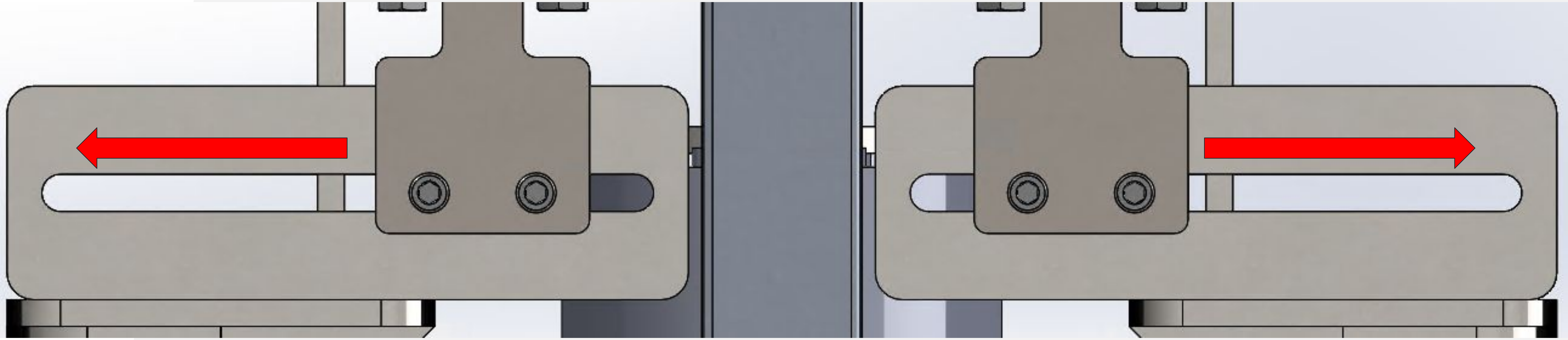
Our team has decided to use a fixed deflection

Rationale:

- Increased confidence in robustness of the load cycling mechanism
- Replicable cycling
- Simplifies design and manufacturing process

How will the necessary stresses be produced in the samples?

<u>Sample dimensions</u> and <u>side roller lengths</u> will require adjustments



Calculation/Selection of fixed deflection:

Max Stress Conditions:

Sample Thickness (in)	0.0625
Sample width (in)	0.5
Length (in)	4.251415548
y (in)	0.03125
Modulus (lbs/in^2)	10000000
Desired Stress (psi)	40250
Calc Stress	40250
Diff	-1.27006E-06
Force (lbs)	6.163694606
Moment =	13.10221354
Moment of Inertia (in^4)	1.01725E-05
Req Deflection (in)	0.097

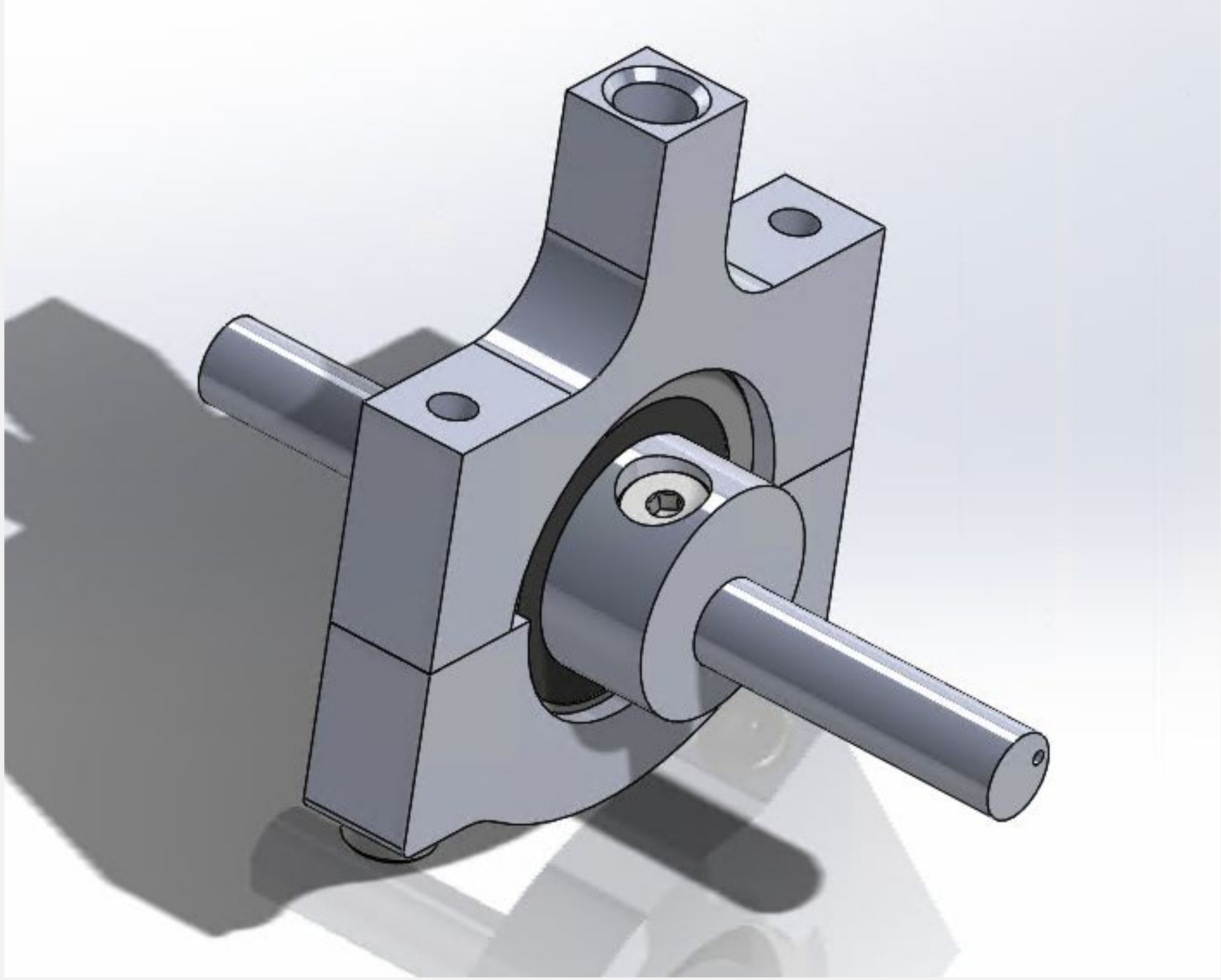
Min Stress Conditions:

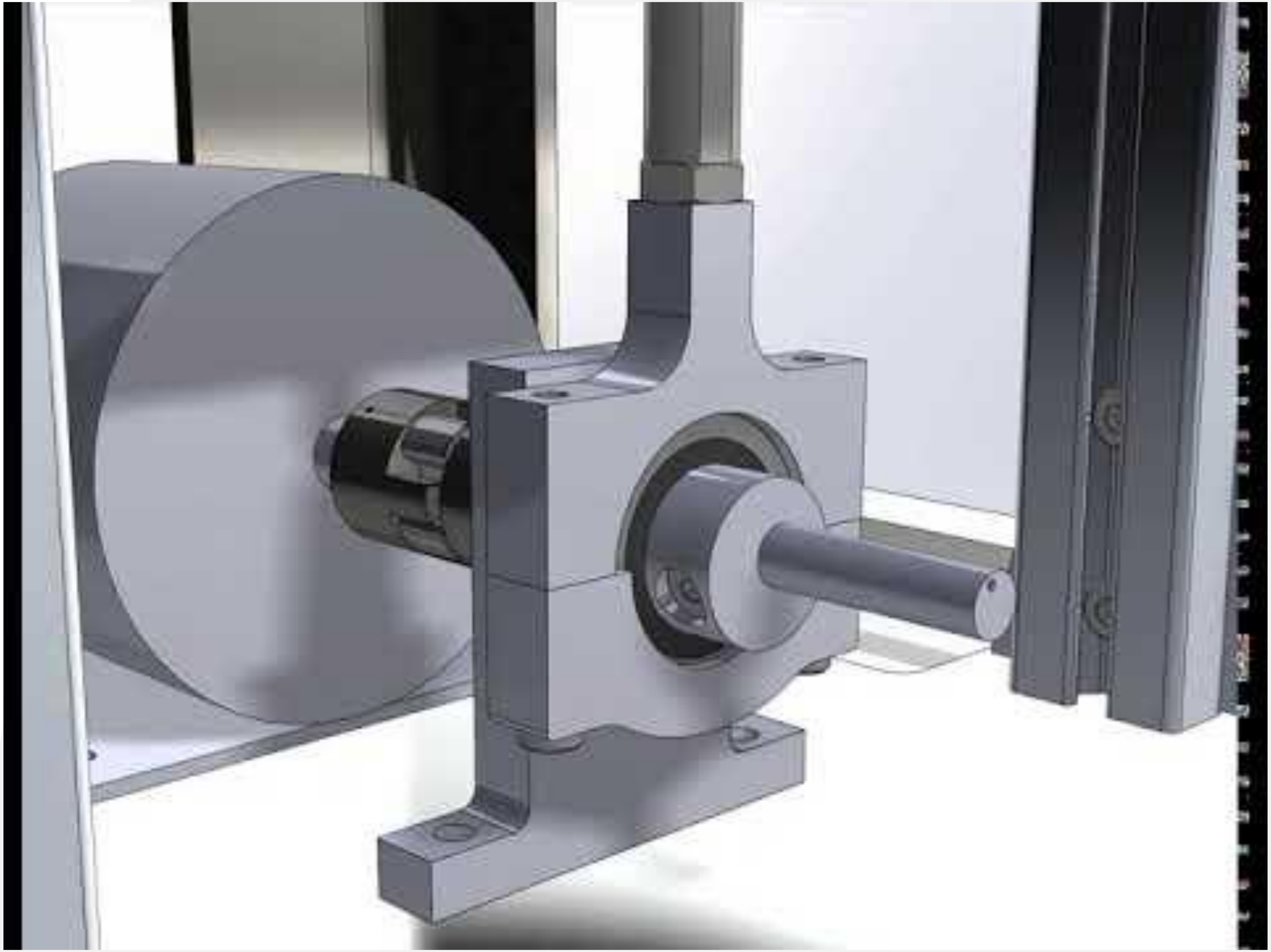
Sample Thickness (in)	0.0625
Sample width (in)	6
Length (in)	11.74370861
y (in)	0.03125
Modulus (lbs/in^2)	10000000
Desired Stress (psi)	5275
Calc Stress	5275
Diff	1.03519E-08
Force (lbs)	3.509192783
Moment =	20.60546875
Moment of Inertia (in^4)	0.00012207
Req Deflection (in)	0.097

Range of Stress: ~5275 - 40,250 Psi

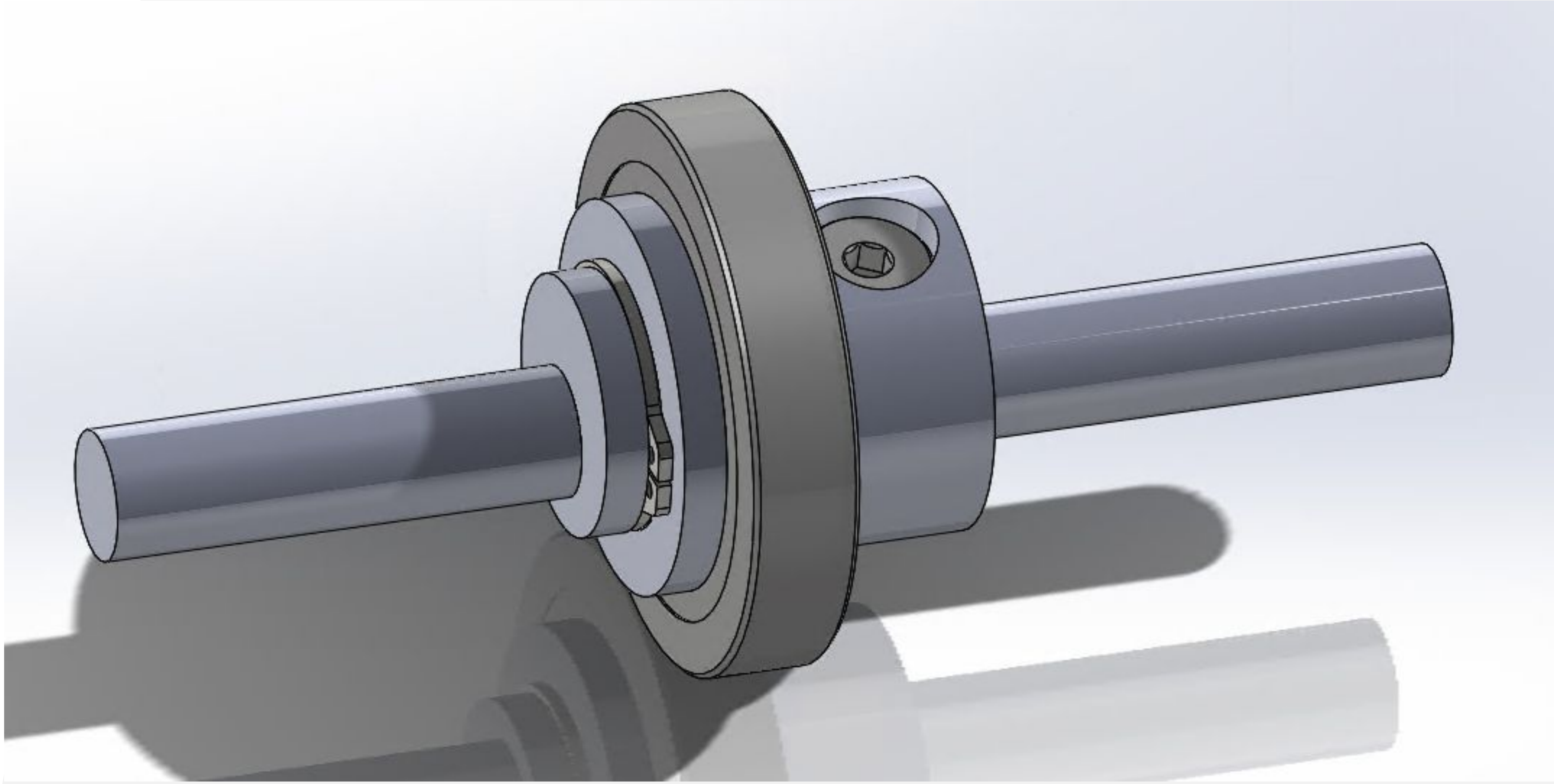
Samples Sizes: Width (0.5 - 6 in), Length (4.25 - 11.74 in)

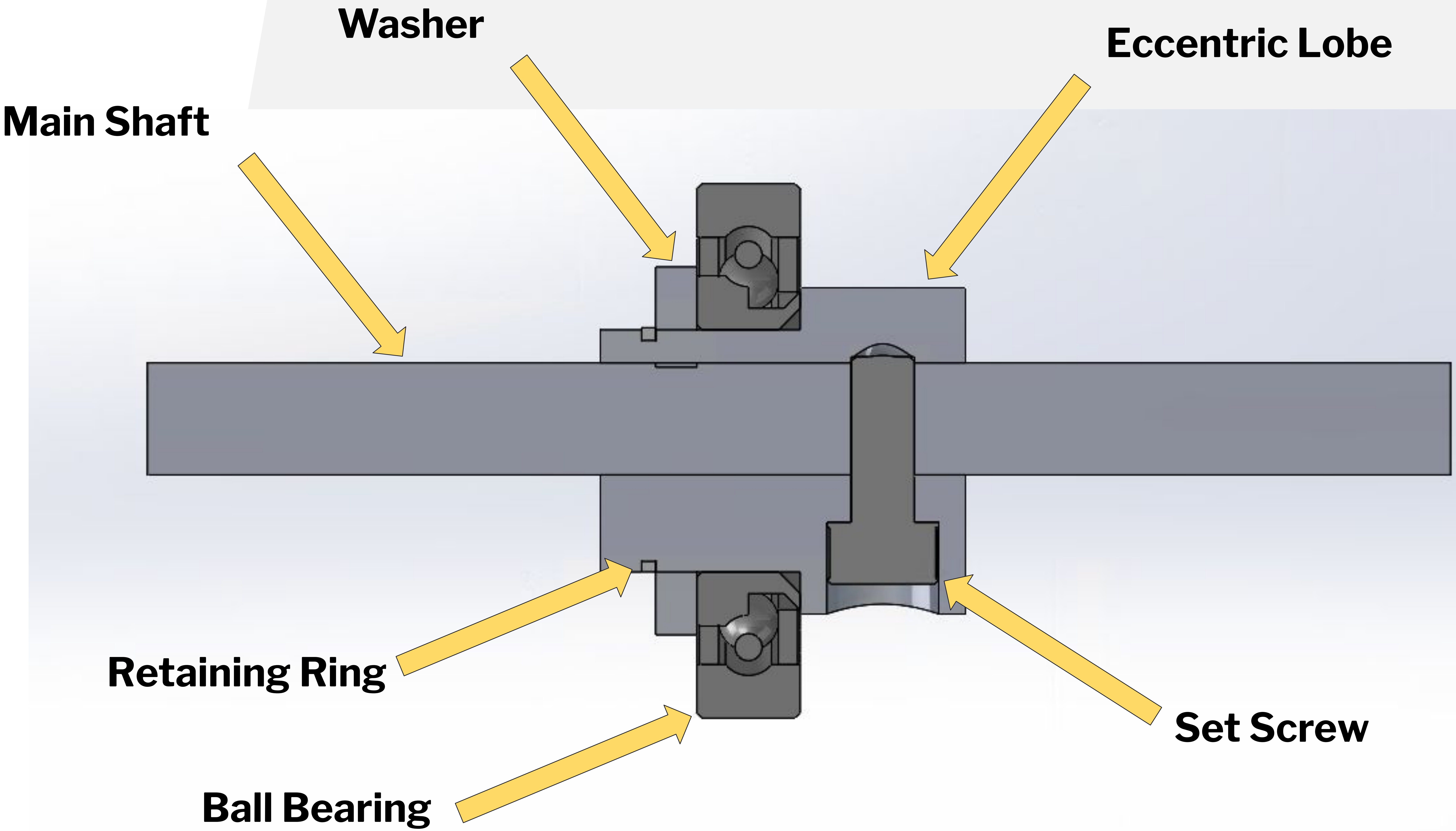
Fixed Deflection Creation: Eccentric Shaft

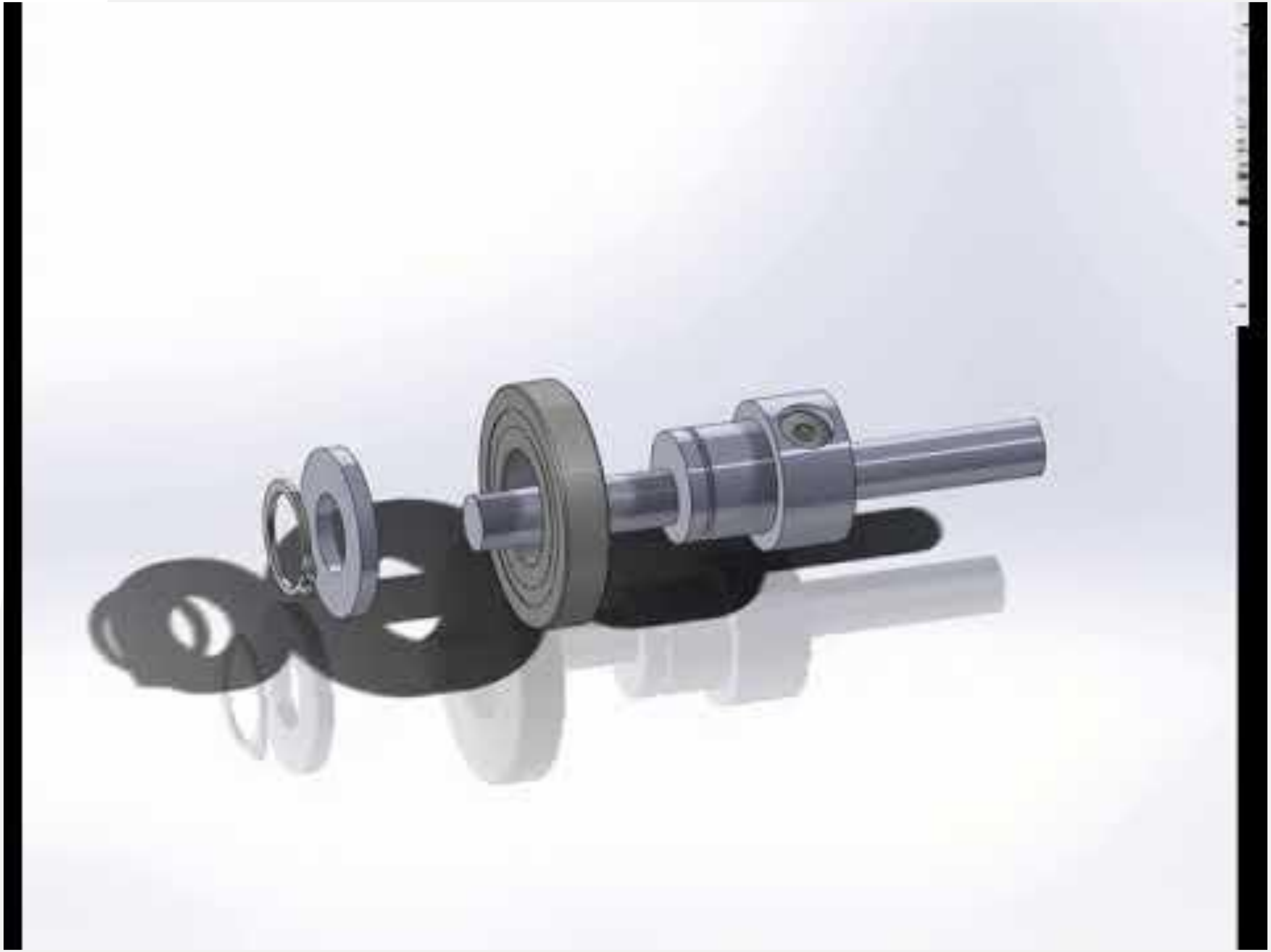




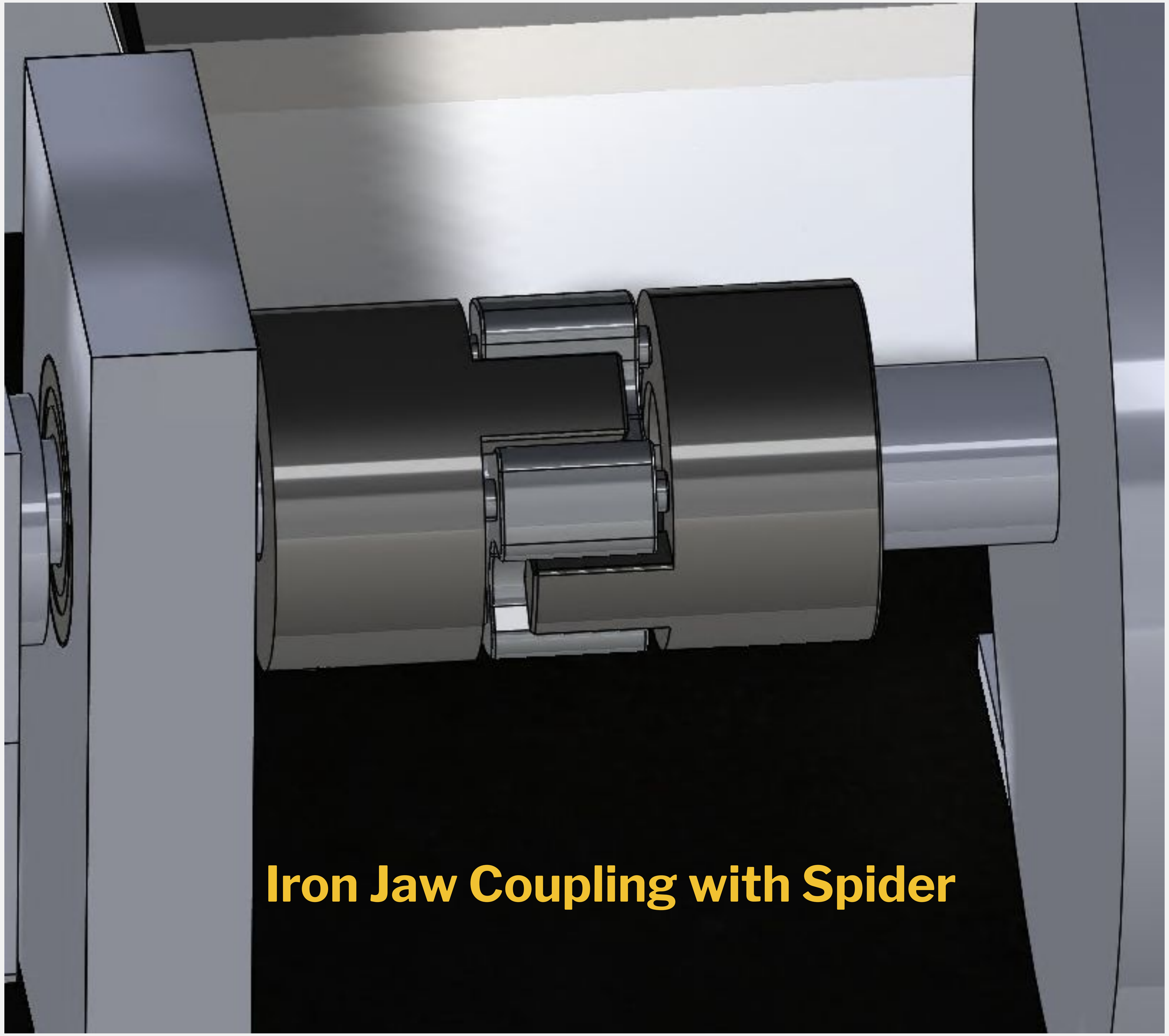
@1000 RPM



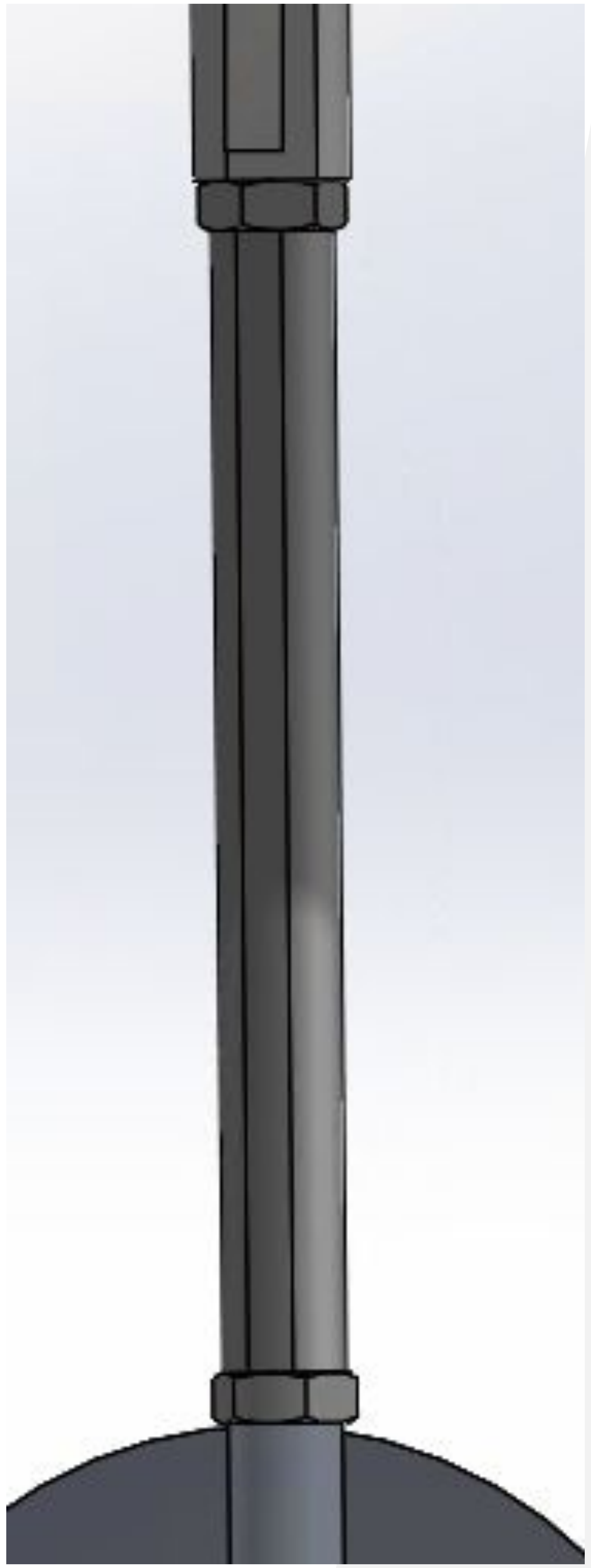

Washer
Eccentric Lobe
Main Shaft
Retaining Ring
Set Screw
Ball Bearing



Alignment Issues / Motor - Eccentric Shaft Coupling



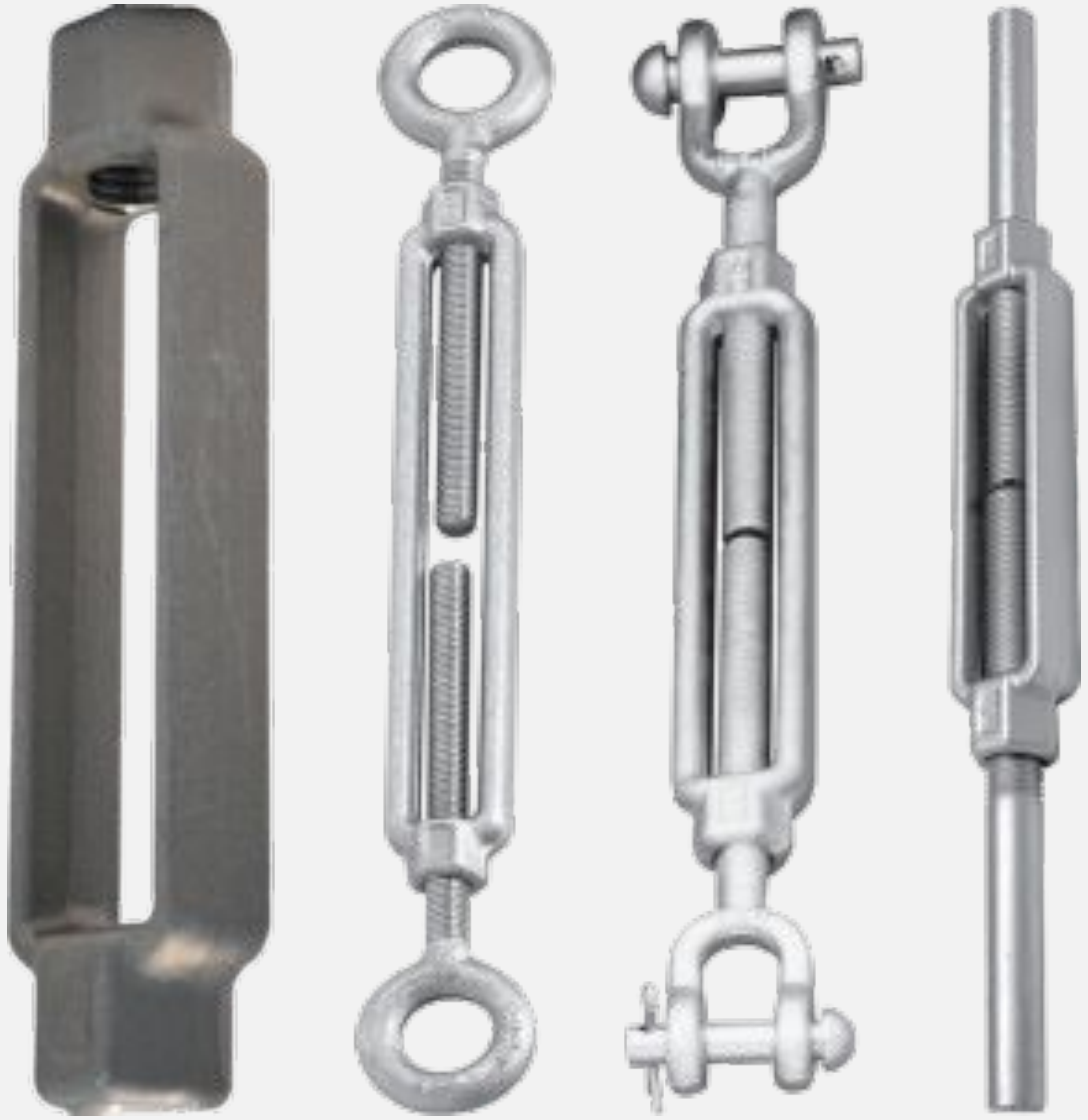
Accommodating Sheet Metal with bends:



This requires an adjustment to the starting position of the center roller.

Turnbuckle Connecting Rod will be used.

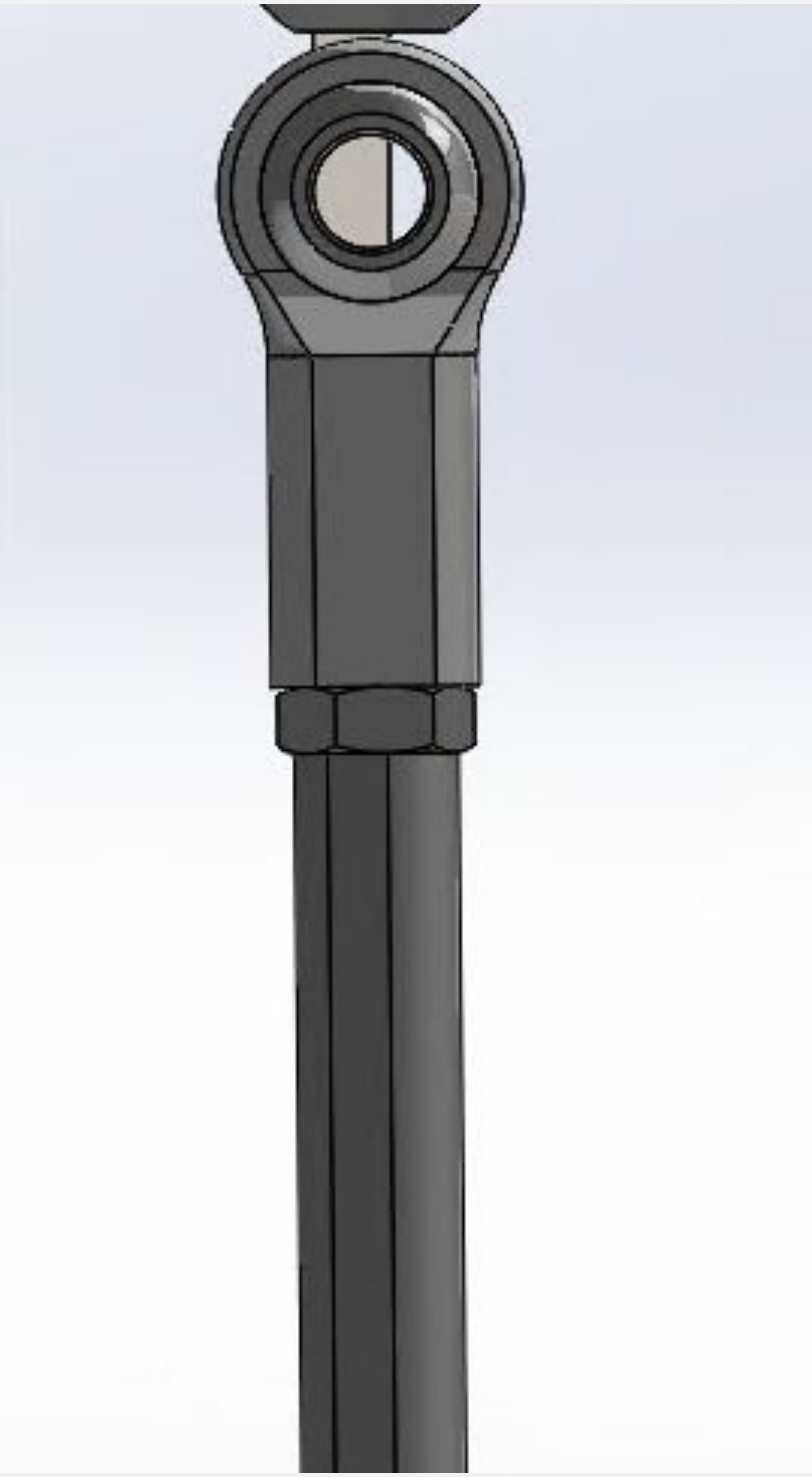
- **Will allow 4” of center roller adjustment.**
- **Will accommodate bends up to 30 degrees**



Attachment to Load Cell Stabilizer:

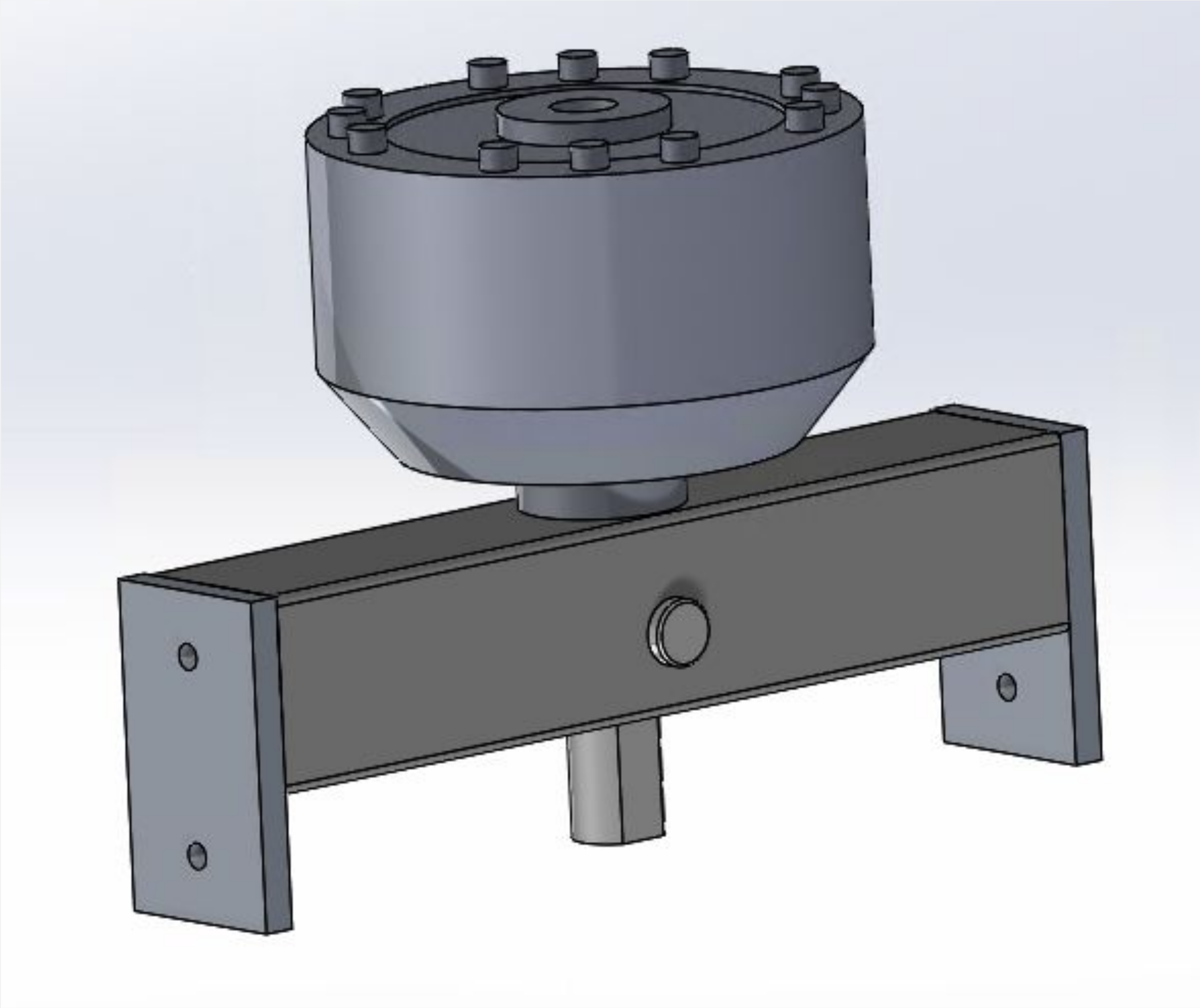
Ball Joint Rod End:

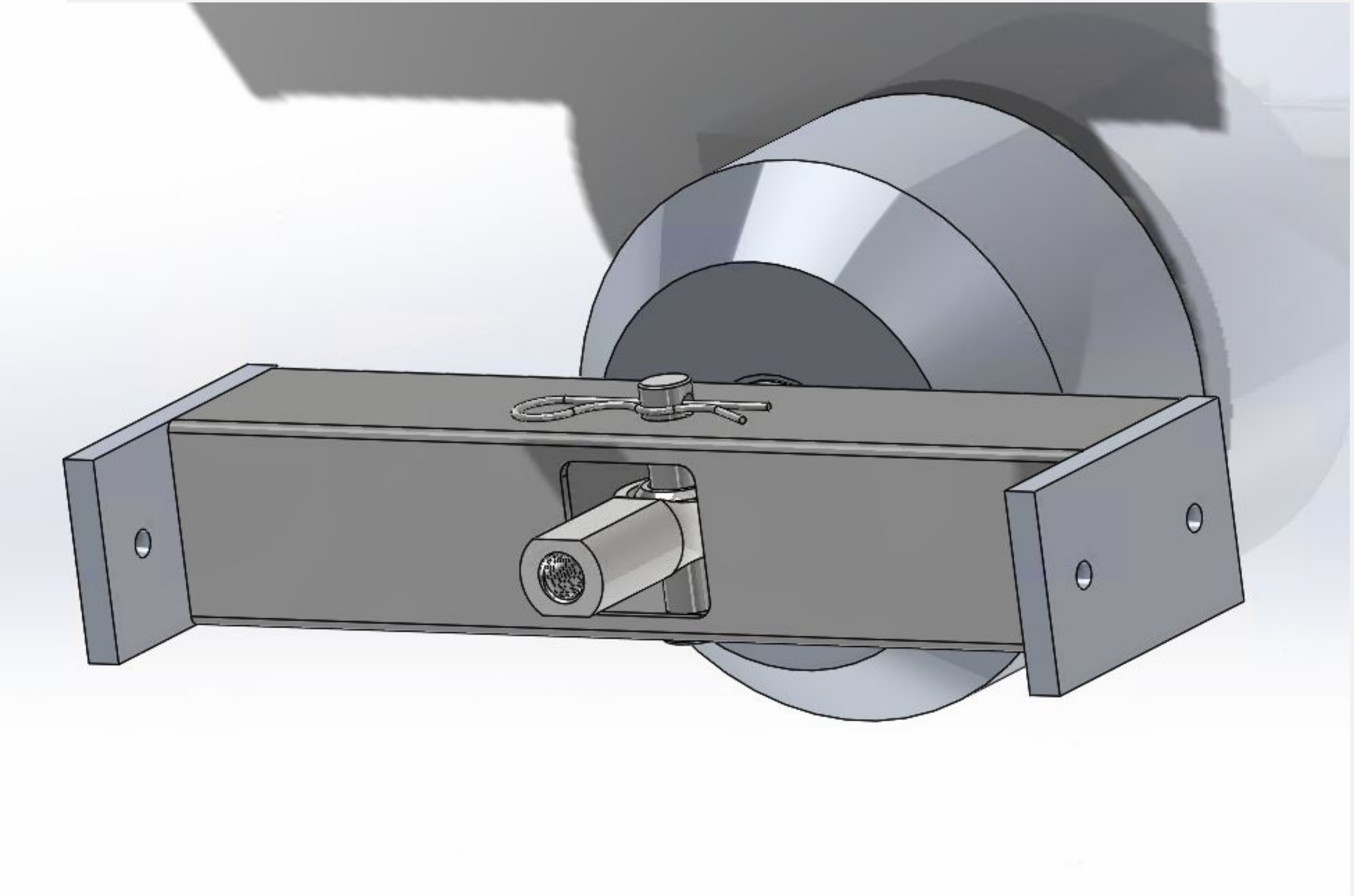
- **Prevent misalignment**
- **Produce the linear displacement of the load cell mount**

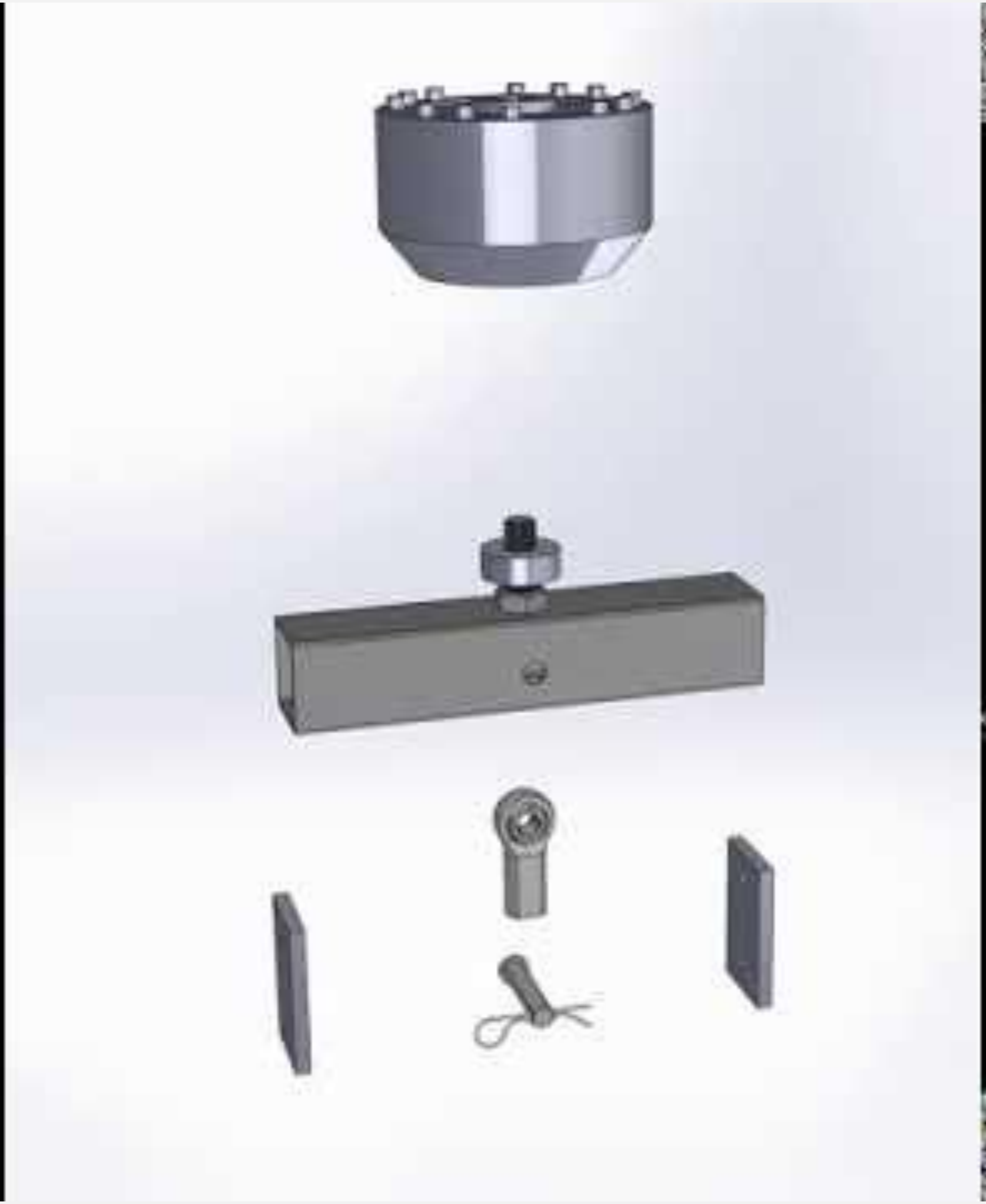


Load Cell Stabilizer:

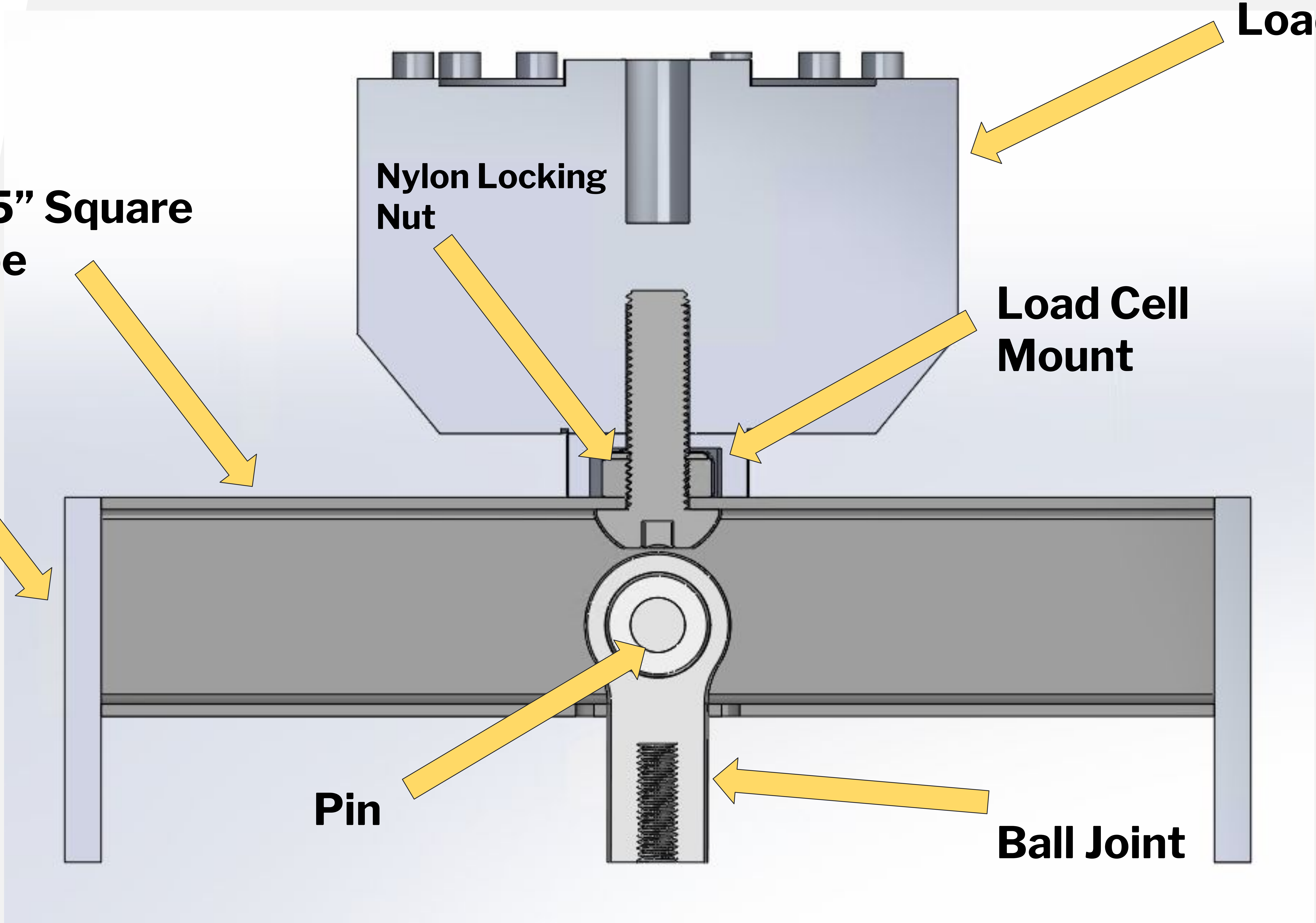
Ensures purely <u>axial loading</u> of the load cell





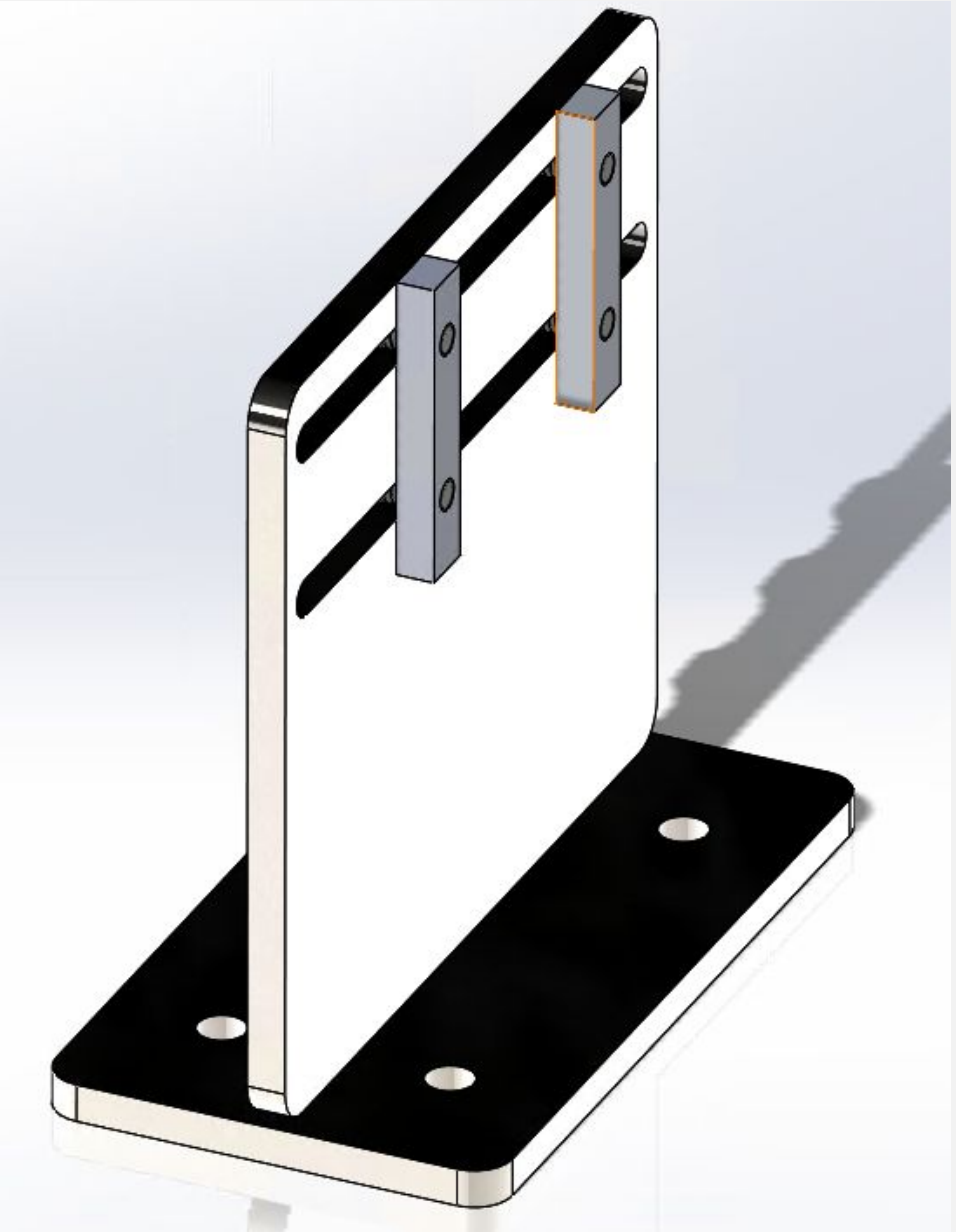


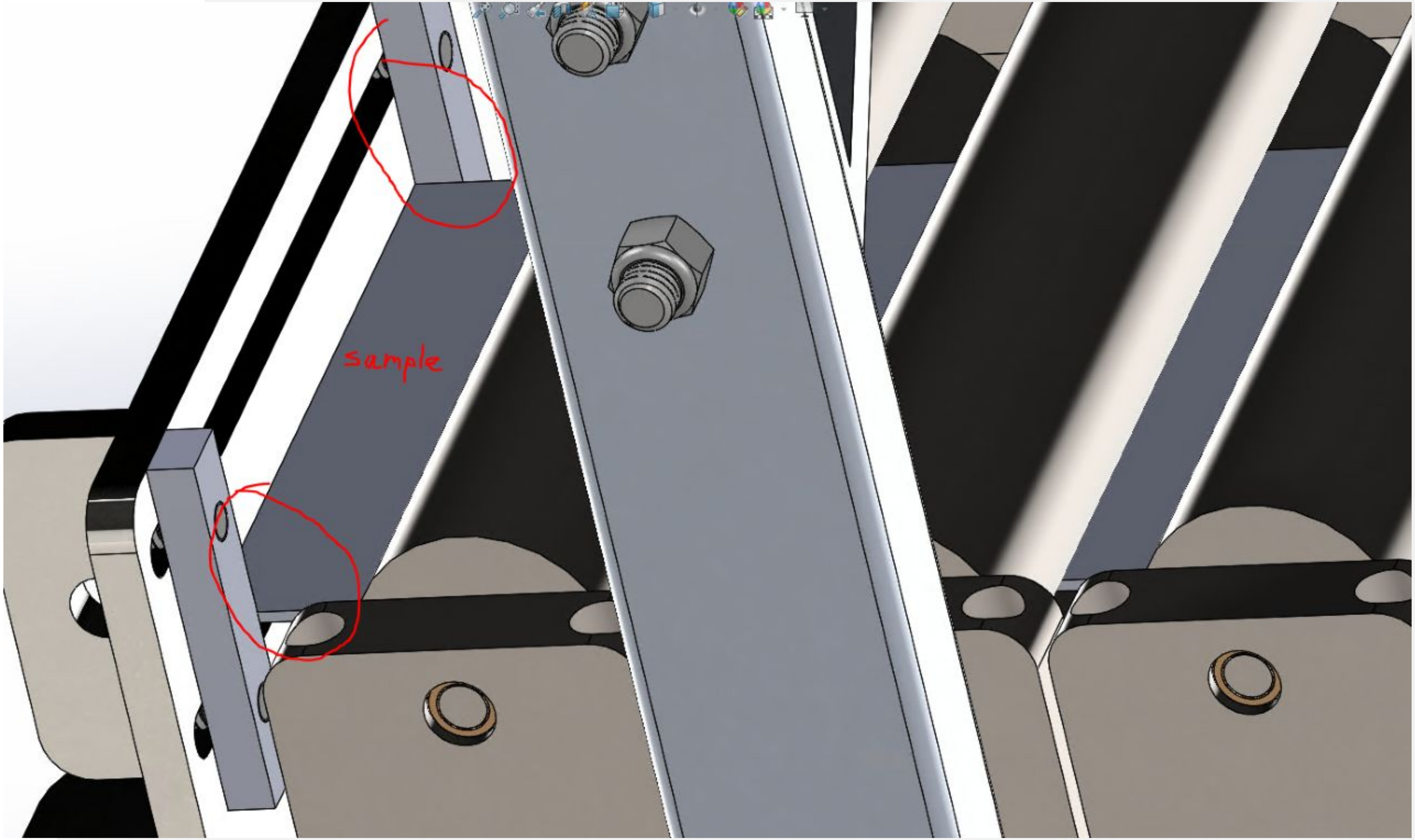
Slot/Pin System to Accommodate Connecting Rod Ball Joint



Updates to L-Bracket Weldment:

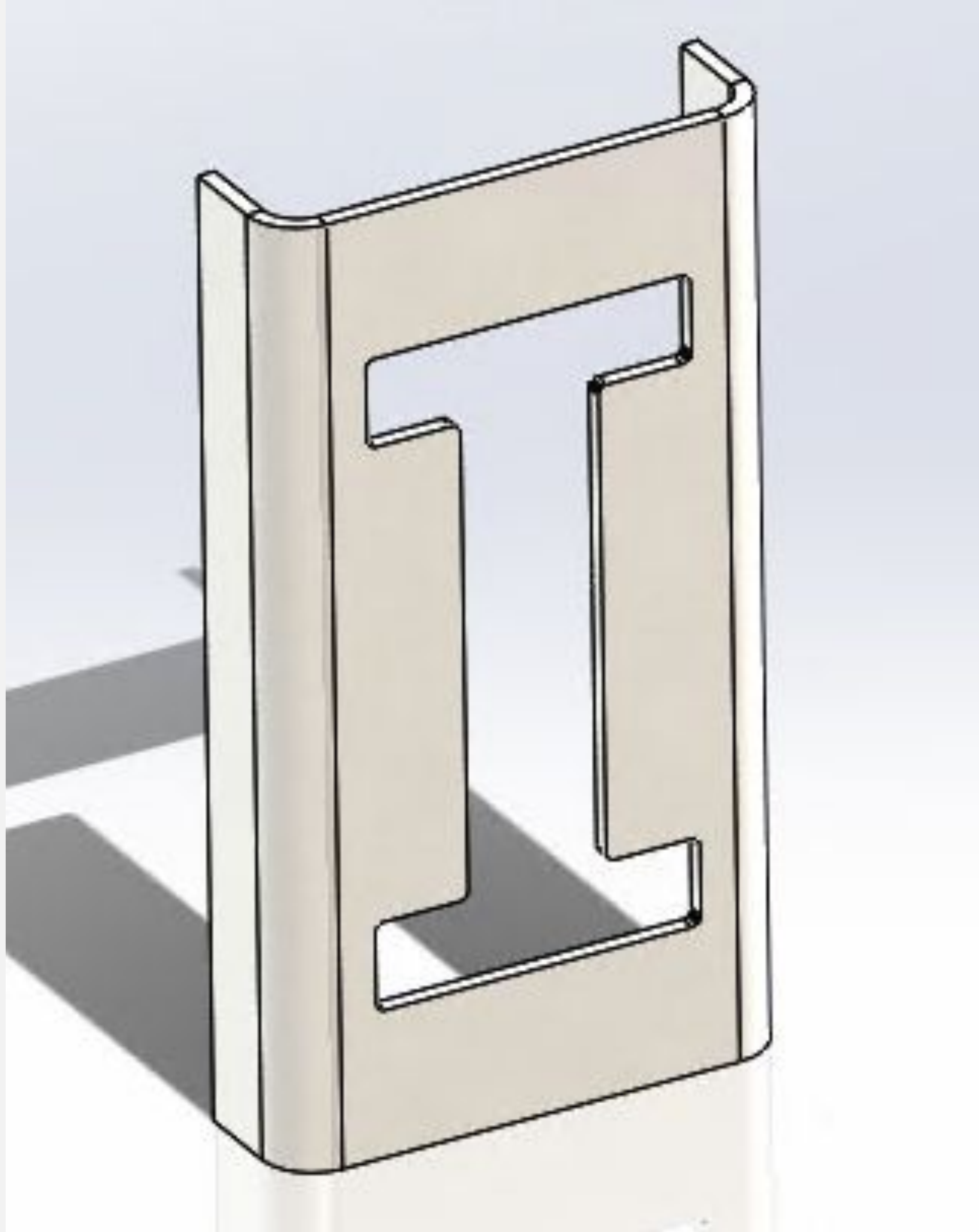
- **Prevents lateral displacement**
- **User will need to give a small gap between the sample and L-Bracket**




sample

Changes to Side Channels:

- **Side weldments height was increased by 4.67”**
- **An arbitrary letter was cut from the side weldment to reduce weight**



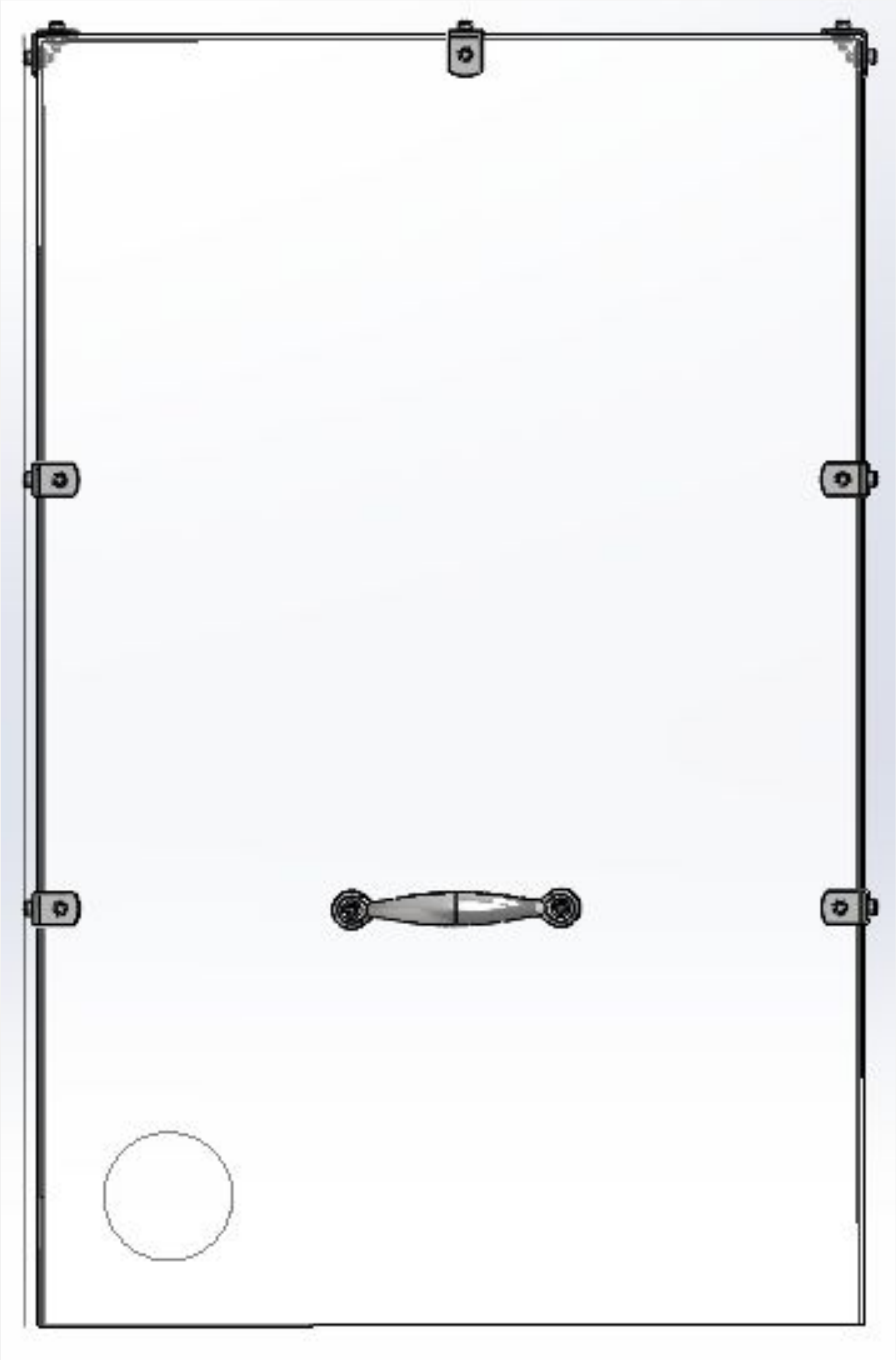
Shielding:

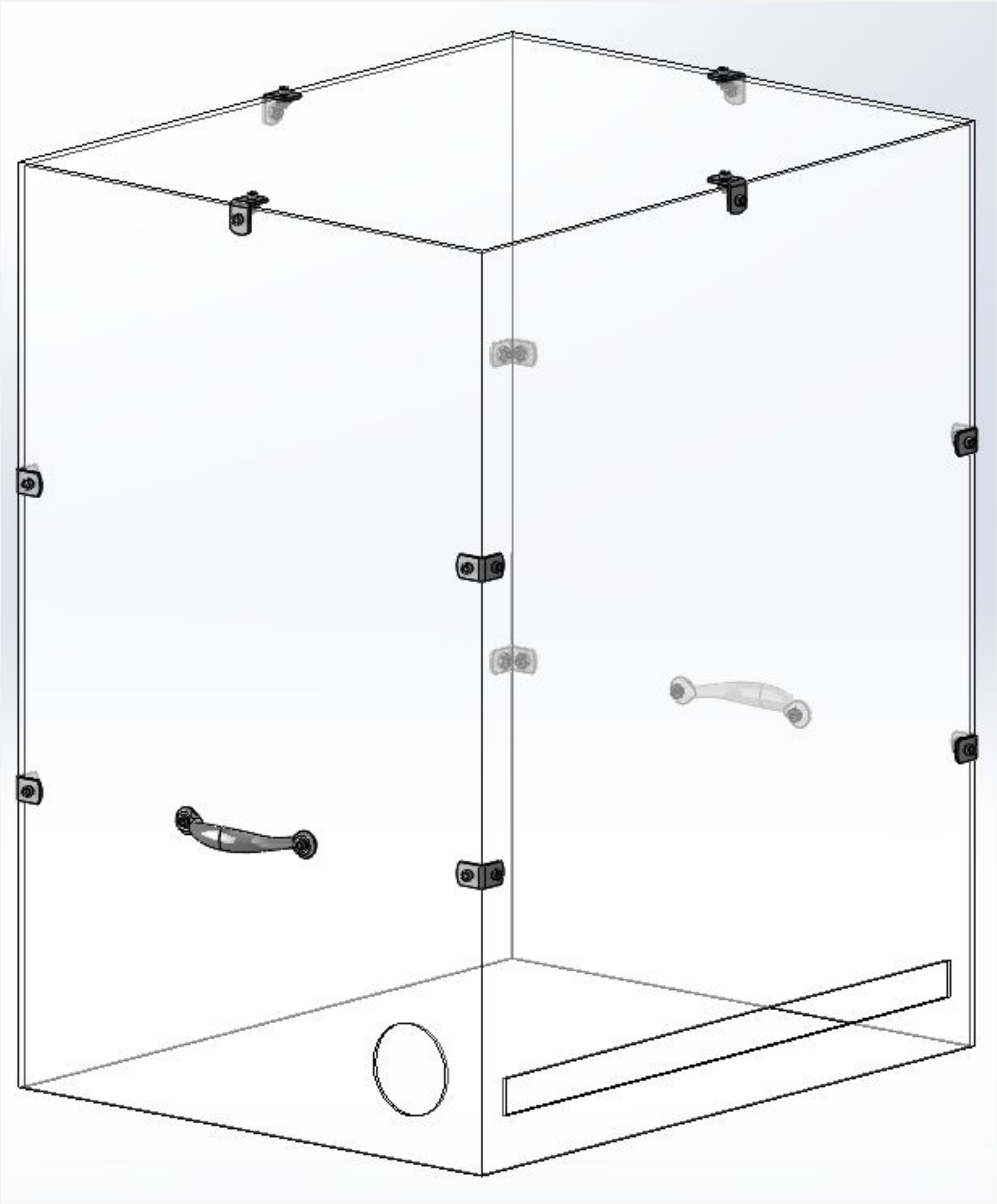
Material: Acrylic Plastic

Thickness: 1/10”

Dimensions: 16x20x25”

Expected Weight: 10 lb





Manufacturing Plan

Make/Buy Analysis:

Manufacturing Plans		
Part	Make or Buy	Source
Eccentric Shaft	Make	ME Machine Shop
Bearing Mounts	Make	ME Machine Shop
Connecting Rod	Make	ME Machine Shop
Shaft Coupler	Buy	McMaster Carr
Load Cell Satbilizer	Make	ME Machine Shop
Frame	Make	UI Facilities

Parts to be Machined:

Eccentric Shaft:

- Lobe
- Shaft
- Bottom/top bearing cover
- Support Bearing Blocks

Load Cell Stabilizer:

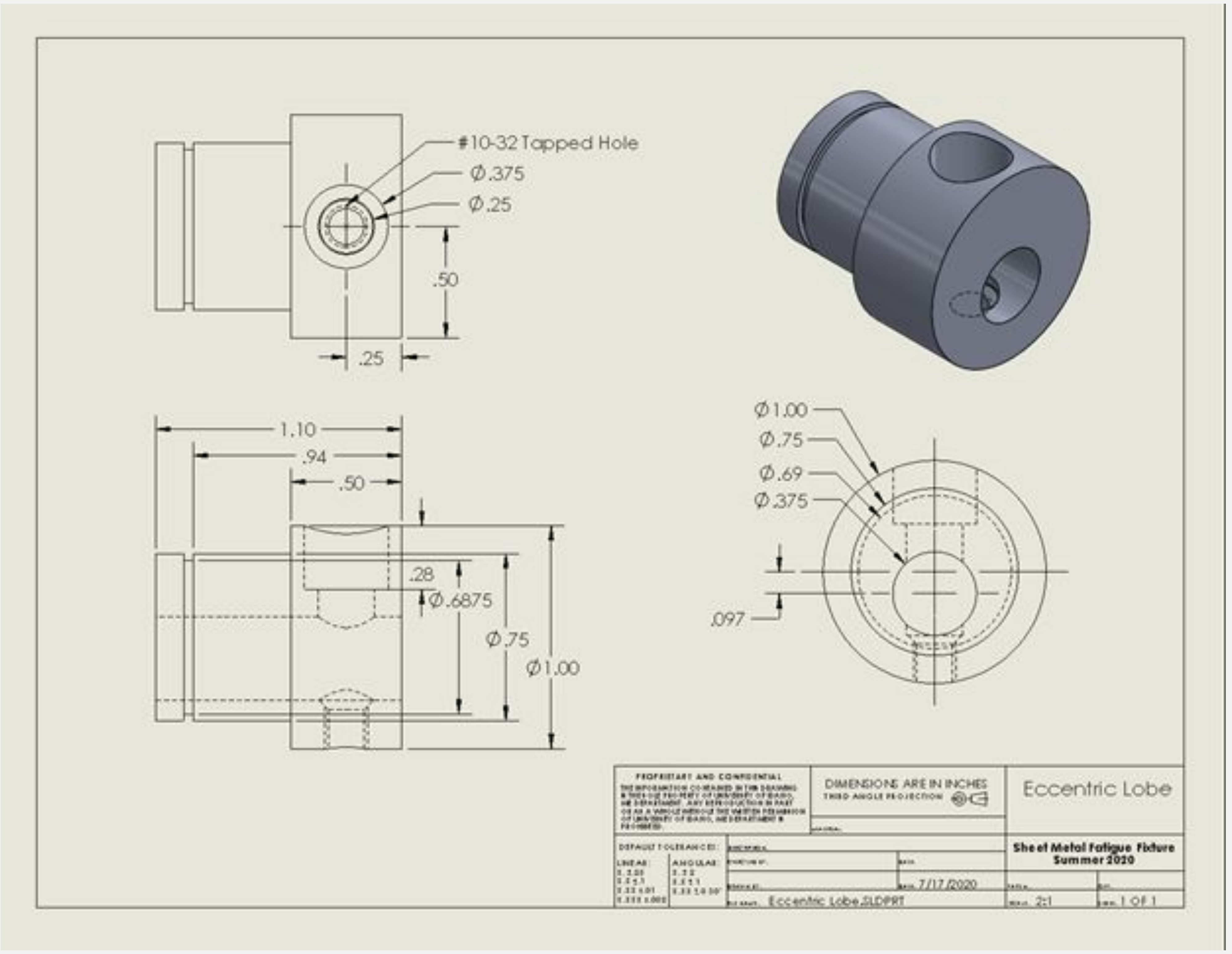
- Square Tube
- Cylindrical Load Cell Mount

Turnbuckle Connecting Rod:

- Threaded connecting rod

Other:

- L-Bracket Supports Blocks



Weldments/Plasma Cuts/Laser Cuts

Weldments:

- Side Roller Support Channels
- L-Brackets
- Top Load Cell Mount

Plasma Cuts:

- All Weldment Components
- Base Plate additions for bearing blocks

Laser Cuts:

- Acrylic Panels

Material Sourcing:

Already on the Benchtop:

- Aluminum Channels have already been purchased
- Baseplate has been cut

Needed Materials:

Catalogs (McMaster/Grainger):

- Square Tubing for Load Cell Stabilizer
- Iron Jaw/Spider Coupling
- All fasteners
- Bearings

Other Raw Materials:

- 0.25” Plate for Weldments (Machine Shop Scraps/Facilities)
- 1” Stock for Eccentric Shaft

Component Fabrication:

Colin Burkhalter (Grad. Mentor)

- Eccentric Shaft
- Bearing Mounts
- Connecting Rod w/ Mounts
- Load Cell Stabilizer
- Acrylic Laser Cuts

UI Facilities

- Frame Weldment
- Plasma Cuts

Completion Goal: Fabrication completed by Friday July 31st*

***Sorry Colin!**

E. Recommendations

Design Features to be Implemented:

- **Ensuring the eccentric lobe starts from its center point for each new test cycle.**
- **Side roller placement system**
- **A one touch UI system that will monitor the sample until it reaches failure, detect the frequency of sample and produce an S-N curve**

F. Risk Mitigation

Risk Register

Risk Register				
Risk Description	**Likelihood of risk occuring**	**Impact**	**Owner**	**Action**
Inaccuarate Load Cell Data	Low	High	Programming Lead	Adjust calibration and circuit
Excessive Heat	Low	Medium	Shielding Lead	Cooling System
Excessive Vibrations	Medium	High	Load Cycling Lead	Impelement more rubber isolators and adjust coupling alignment
Parts Delay	Low	High	Load Cycling Lead	Design parts for quick machining and order purchased parts early
Part Fitment Issues	Medium	Medium	Load Cycling Lead	Address fitmet issues and workout a solution

G. Design Validation

Project schedule and budget with guidelines on how our project fits within these constraints:

Senior Capstone Design

Project: Sheet Metal Fatigue Fixture

Team: Get Bent

Primary Author:

Last Updated: 7/17/2020

Design Validation Plan & Results (DVP&R)

Requirement	Test	Test Subject	Target Date	Result	Recommendation
Detect if load cell values fluctuate	Start a sample test while connected to GUI interface	Using FailureDetection.cs to monitor the code output	7/24/20		
Protecting Shielding shall not excced 20 lb	Measuring the weigh scale in GJ 126	Fully Functional Prototype will be weighed	8/5/20		
Calculate speed using Hall Effect Sensor	Start a sample test while connected to GUI interface	Using SpeedController.cs to monitor the code output	7/24/20		
Fixture shall not excced 70 lb	Measuring the weigh scale in GJ 126	Fully Functional Prototype will be weighed	8/5/20		
Device shall handle up to 40 Ksi static pressure	Calculating stress capacity when the full prototype assembled	Fully Functional Prototype will be tested with samples that generate various presures	8/5/20		
Shielding should not excced 36x36x60 in (max)	Using SolidWorks dimension for the system assembly	Fully Functional Prototype will be measured	7/24/20		
Operational noise shall not exceed 80 decibels.	Using a noise detection device to measure the decibels	Fully Functional Prototype will be turned on and compared to known values.	8/5/20		
Should be able to fit in a desktop	Visual	Fully Functional Prototype will be measured on a bench	8/5/20		
Eliminate all pinch points on the fixture.	Visual	Fully Functional Prototype	8/5/20		

H. Schedule and Budget

Project schedule and budget with guidelines on how our project fits within these constraints:

Capstone Project Budget Template - Summer/Fall

Project:

Last Updated 6/15/2020

Expense Items	June	July	Aug	Sept	Oct	Nov	Dec	Item Total		
	2020									
Equipment/Tools:										
								$ -		
Travel:										
								$ -		
								$ -		
Supplies / Parts / Services:										
Acrylic	$ 50							$ 50		
Steel		$ 100						$ 100		
Hardware								$ -		
Bearings		$ 50						$ 50		
Bolts		$ 10						$ 10		
Ball Joints		$ 10						$ 10		
Misc.		$ 15						$ 15		
								$ -		
Misc Circuit Components	$ 50							$ 50		**Expenses**
									$ 285	**Subtotal**
ME Shop Usage (est. Hrs):								Hours		
CNC Mill		20						20		
CNC Lathe		10						10		
Welding		5						5	$ 212.5	
								0		
								0		
								0		

Graduate Student Support (only for SEA projects)	$ -	**including fringe (2.1%)**
Shop Overhead (only for SEA projects)	$ -	
University Overhead (only for SEA projects)	$ 28.57	**5% of all expenses**
Totals	**$ 526**	**$ 600** (Budget) $ 74 (Excess)

Note: With many parts purchased we will be critical of making major design changes that do not allow us to used purchased materials from the previous team. Our budget is restricted to critical components like acrylic for shieling and time to machine new parts with recycled material.

Project schedule and budget with guidelines on how our project fits within these constraints:

	Snapshot deadline
	Docs

* = an automatically calculated cell

TASK NAME	START DATE	Project Day*	END DATE	DURATION* (WORK DAYS)	DAYS COMPLETE*	DAYS REMAINING*	LME (Lead Engr)	PERCENT COMPLETE
Team Milestones								
Project Bid Portfolio	6/15	1	6/16	1	1	0	Camille	100%
Team Contract	6/16	2	6/22	6	6	0	Camille	100%
Budget	6/16	2	6/22	6	6	0	Jayden	100%
Client Interview	6/21	7	6/22	1	1	0	All, Dr. S	100%
PRD (Product Req)	6/22	8	6/25	3	3	0	Camille	100%
Project Schedule	6/25	11	7/2	7	7	0	Camille	100%
Design Validation	7/3	19	7/10	7	7	0	TBD	100%
Portfolio/Logbook/Wiki Check	7/3	19	7/10	7	7	0	Camille	100%
Snapshot (7/13)	7/12	28	7/13	1	1	0	All	100%
Design Review	7/12	28	7/16	4	0	4	TBD	0%
Value Proposition	7/17	33	7/20	3	0	3	Camille	0%
Snapshot Story Board	7/20	36	8/6	17	0	17	TBD	0%
Snapshot Tech Presentation	7/20	36	8/6	17	0	17	TBD	0%
Snapshot (8/6)	8/3	49	8/6	3	0	3	All	0%
Final Project Submissions (8/7)	8/6	52	8/7	1	0	1	All	0%

Next Steps:

Begin manufacturing process ~July 31st

Order necessary parts - This Week

Calibrate Load Cell - This Week